

AIR QUALITY DRYDEN

Annual Report, 1976

1976-1977
MINISTRY OF THE ENVIRONMENT

FEB 7 - 1978

TD883.7
D7
A57
1976
MOE

c.1
a aa



Ontario

Ministry
of the
Environment

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact ServiceOntario Publications at copyright@ontario.ca

AIR QUALITY

DRYDEN

Annual Report, 1976

ONTARIO MINISTRY OF THE ENVIRONMENT

October, 1977



Environment Ontario

Laboratory Library
125 Resources Rd.
Etobicoke, Ontario M9P 3V6
Canada

TD883.7/D7/A57/1976/MOE

ASMP

CONTENTS

SUMMARY	1
INTRODUCTION	2
VEGETATION AND SOIL ASSESSMENT	
(a) Urban Vegetation and Soil	2
(i) Trembling Aspen and Soil	2
(ii) Manitoba Maple	4
(b) Moss Bag Exposure Experiment	4
SNOW SAMPLING	5
AIR MONITORING	
(a) Dustfall	7
(b) Sulphation Rates	8
ACKNOWLEDGEMENTS	9
REFERENCES	10
FIGURES AND TABLES	11-26

SUMMARY

Air quality studies in Dryden, begun by the Ontario Ministry of the Environment in 1970, continued in 1976 with vegetation and soil sampling, a moss bag exposure experiment, snow sampling, dustfall measurement, and sulphation rate monitoring. The purpose of these operations was to assess the effects of emissions from a kraft pulp mill and chlor-alkali plant on local air quality and nearby terrestrial environment.

Mercury concentrations decreased significantly from 1975 to 1976 in vegetation samples collected near the mill area. This decline was attributed to the termination, in late 1975, of the use of mercury in the chlor-alkali plant. In contrast, mercury levels in soil showed little change from 1975 to 1976. Residual airborne mercury contamination was also demonstrated in samples of *Sphagnum* moss exposed during the summer.

The mercury content of snow samples also decreased sharply from 1975 to 1976, although residual mercury levels were still well above concentrations found in uncontaminated snow. High concentrations of calcium, sodium and sulphate, all attributed to mill emissions, were recorded in snow near the mill at levels similar to those encountered in 1974 and 1975.

Dustfall in Dryden frequently exceeded the monthly and annual criteria prescribed under Ontario regulations. Sulphate, probably emitted as sodium sulphate from the kraft mill, accounted for a large proportion of total dustfall. Both total dustfall and sulphate in dustfall decreased significantly when the mill was shut down during the summer.

Sulphation rates, a measure of the presence of sulphur-containing gases in the air, were highest near the mill and decreased with increasing distance. Sulphation rates at all monitoring sites were much lower during mill shutdown than during the rest of the year.

INTRODUCTION

The Ontario Ministry of the Environment has conducted an air quality monitoring programme in Dryden since 1970, when airborne mercury levels were first measured with equipment in a mobile van. Several different types of air quality investigations, described in more detail in an earlier report (1), have been carried out since that date. Vegetation, soil, and snow have been sampled, and both gaseous and particulate pollutant levels have been monitored. All this work has been concentrated in the vicinity of Dryden's principal industrial source of air pollution, a 625 ton-per-day bleached kraft pulp mill and associated chlor-alkali chemical plant.

Data obtained up to the end of 1975 indicated that snow near the mill contained elevated concentrations of calcium, mercury, sodium and sulphate. Mercury was also moderately elevated in local vegetation and soil. Hydrogen sulphide was the only gaseous pollutant found at concentrations above Ontario regulations. Insufficient data were available to permit calculation of average levels of particulate contamination.

In 1976, vegetation foliage was collected for chloride, mercury, and sodium analysis. Moss, exposed to the air at selected sites, was also analysed for the same elements, plus calcium. A snow sampling survey, first undertaken in 1974, was repeated in 1976. The dustfall and sulphation rate monitoring network was expanded from three sites to six and dustfall for most months in the year was analysed for sulphate content.

VEGETATION AND SOIL ASSESSMENT

- (a) Urban Vegetation and Soil
 - (i) Trembling Aspen and Soil

Vegetation and surface soil sampling conducted during the 1975 growing season revealed the presence of a small zone of mercury contamination near the kraft mill and associated chemical

plant. Mercury levels in both vegetation and soil decreased with increasing distance from the mill area.

In late 1975, the mercury-cell process in the chlor-alkali chemical plant was converted to a membrane-cell operation which eliminated the use of mercury. To determine whether this change had affected mercury levels in local vegetation and soil, the 1975 vegetation and soil survey was repeated in 1976.

Triplicate samples of foliage from trembling aspen (*Populus tremuloides*) trees and soil were collected in mid-August from 13 sites in Dryden and two controls (Figure 1). Each foliage sample comprised about 500 g(grams) of fresh leaf material placed in a labelled, perforated polyethylene bag which was then stored under refrigerated conditions pending air shipment to processing and analytical facilities in Toronto. Soil was obtained from undisturbed areas with a stainless steel corer, 2.5 cm (centimetres) in outside diameter. Surface debris and visible organic matter above the soil was removed before each insertion of the corer. Each core was separated into fractions representing depths of 0-5 and 0-10 cm, with any excess being discarded. Material from at least 10 cores were pooled to form one composite sample which was placed in a labelled plastic bag for shipment. Before analysis, foliage was oven dried at 80°C for 30 hours, then ground in a Wiley mill. Soil was air dried for 48 hours, pulverized with a wooden mallet, coarsely screened to remove stones and organic matter, then finally screened through a 40-mesh sieve. The mercury content of processed samples was determined by flameless atomic absorption spectrophotometry, with a detection limit of 20 ng(nanograms)/g.

Mercury levels found in trembling aspen and soil in 1976 are compared in Table 1 with those found in 1975. With one exception, foliar mercury concentrations near the mill decreased significantly from 1975 to 1976, while controls showed little change. This improvement is illustrated by contour maps in Figures 2a and 2b. In contrast, mercury in soil at most sites remained at about the

same level in both years." The modest increase in soil mercury concentrations recorded at a few locations was attributed to normal variations expected in a soil sampling survey and not to differences in emissions from the source investigated. Mercury levels in soil near the Dryden chlor-alkali plant were, however, much lower than those in soil at equivalent distances from two other mercury-cell chlor-alkali plants in Ontario (2,3).

(ii) Manitoba Maple

Because of the scarcity of trembling aspen trees in the commercial-residential area of Dryden, Manitoba maple (*Acer negundo*) was substituted as a sample species in the town area. Eleven sites were selected, plus two, out-of-town controls (Figure 3). Samples were collected and processed as described above for trembling aspen and soil. Mercury and sodium concentrations were determined by atomic absorption spectrophotometry and chloride by colorimetry. Detection limits were 0.02 µg/g, 0.4 µg/g, and 200 µg/g, respectively.

Chemical analysis results for Manitoba maple are reproduced in Table 2. Mercury levels in the survey area were somewhat higher than those at control sites but all were well below the concentration (1.0 µg/g) considered indicative of significant contamination. There was no gradient of decreasing concentration with increasing distance from source. A few of the chloride and sodium concentrations were also slightly above the controls, but were not considered excessive. However, since the mill was not operating from mid-June to late September, high contaminant levels were not expected in any case.

(b) Moss Bag Exposure Experiment

Mosses have been found effective in absorbing and retaining airborne contaminants (4) and techniques have been developed for suspending moss in bags as passive monitors of the atmospheric environment (5). In an experimental survey at Dryden, moss bags

were exposed for two, one-month periods from mid-May to mid-September, 1976, at 25 sites near the pulp mill and at two control locations (Figure 4). Each sample consisted of 3 g of oven-dried *Sphagnum* moss in a 10 x 20 cm envelope of fibreglass screening attached with adhesive tape to a supporting structure about 2.5 m (metres) above ground level. Before being dried, moss was washed in 0.5 molar nitric acid to strip away any contaminants present before exposure in the field and to encourage a higher rate of contaminant deposition and retention during the exposure period. After exposure, samples were analysed for calcium, chloride, mercury and sodium, using the same processing and analytical techniques described for trembling aspen and Manitoba maple.

Chemical analysis results are summarized in Table 3. Concentrations of chloride and sodium were low near the mill and not significantly different from those at control sites. Although the mill was shut down during both moss bag exposure periods, some moderately elevated calcium levels were found close to the mill. There was, however, a poorly defined gradient of decreasing calcium content in moss with increasing distance, and the highest value recorded was well below those found near other kraft pulp mills in northwestern Ontario (2,6). Unlike the other elements, mercury showed a clear trend of progressively decreasing concentration with increasing distance from the mill area (Figure 5). This finding was unexpected since the mercury-cell process had been terminated in the chemical plant in 1975. Remnants of mercury contamination in or near the plant may be causing elevated concentrations of mercury to persist in the local atmosphere.

SNOW SAMPLING

Snow sampling has been found useful as an indicator of the kind, amount, and extent of particulate pollutants around industrial sources of air pollution. The adverse environmental effects, if any, of the presence of some contaminants in snow has not yet

been established, nor have regulations been developed to define acceptable levels of snow pollution. However, guidelines have been established for concentrations of several elements in snow, based on a number of northern Ontario surveys. For the kraft pulp mill industry, levels above 5 mg/l for calcium, 0.5 µg/l for mercury, 10 mg/l for sodium, and 10 mg/l for sulphate are considered excessive.

Results of snow sampling surveys conducted in Dryden in early 1974 and 1975 were discussed in an earlier Ministry report (1). Another survey was conducted in February, 1976, primarily to determine what changes in mercury levels might have occurred following conversion of the chlor-alkali plant to a non-mercury process. Sampling sites were the same in 1975 and 1976. Samples were obtained from undisturbed snow, with preference for areas sufficiently open to permit the free fall of snow, but not subject to excessive drifting. Areas thought to be affected by contaminants from roads or other extraneous sources were avoided. Each site was mapped, and information was recorded on site description, snow condition and snow depth. The kind and amount of visible particulate contamination on and below the snow surface was also noted. Each sample comprised a surface area of about 50 cm by 50 cm and a depth of 20 cm. Snow was collected with a clean, plastic shovel, placed in large, heavy-gauge polyethylene bags, and retained in unmelted condition until processed. The snow was then melted indoors in clean plastic pails pre-rinsed with distilled water. Measurement of pH was made when melting was completed (usually 12 to 18 hours). Meltwater was then vigorously stirred to suspend particulate matter, and poured into clean, 1-litre, plastic bottles for submission to the Ministry's Thunder Bay Regional Laboratory. Samples for metal analysis were preserved by adding 20 drops concentrated nitric acid per sample bottle. Meltwater for mercury analysis was further preserved by adding sufficient saturated potassium permanganate solution to impart a

slight purple colour to the sample water. Calcium analysis of meltwater was conducted by EDTA titration, mercury by flameless atomic absorption spectrophotometry, sodium by atomic absorption spectrophotometry and sulphate by methyl thymol blue colorimetry.

Average total depth of snow cover on sampling dates in 1976 was 41 cm. Fresh snow (that which fell in the 10-day period before sampling) constituted about half of each sample. Heavy deposition of black particulate matter, possibly bark char or lignite, was observed on and below the snow surface at three sites close to the mill, with lesser amounts recorded up to a distance of 2000 m. Sawdust was noted only at site 6, just south of the chemical plant. The occurrence and distribution of visible particulate matter in snow was about the same in 1975 and 1976.

Chemical analysis results for the 1976 survey are presented in Table 4 and plotted in Figures 6 to 8. The concentration and distribution of calcium, sodium, and sulphate was about the same in 1975 and 1976. Levels of pH, thought to be related primarily to the presence of calcium, were also similar in 1975 and 1976. Mercury concentrations, though much reduced in 1976, were still well above background levels, indicating apparent effects of lingering contamination. Guidelines for excessive concentrations of all elements studied were exceeded in the 1976 survey at Dryden.

AIR MONITORING

(a) Dustfall

Dustfall, one of the most visible classes of air pollutants, comprises particulate matter which settles out from the atmosphere under the influence of gravity. It is measured by exposing open-top vessels for 30 days and weighing the collected matter. Results are expressed in tons per square mile per month. In addition to total dustfall, the amount of soluble sulphate in dustfall was also determined for most months during the year.

Figure 9 shows the arrangement of dustfall monitoring sites. Dustfall levels for 1976, summarized in Table 5 and plotted in Figure 10, reveal several interesting features. The monthly Ontario criterion for total dustfall was exceeded frequently at locations near the pulp mill, and the annual criterion was exceeded at all but one of six sites. Dustfall levels decreased with increasing distance from the mill area (Figure 10). High sulphate levels were associated with high dustfall. Occasionally, sulphate alone was above the monthly provincial criterion for total dustfall. Sodium sulphate (saltcake) probably accounted for much of the soluble sulphate measured in jars. If all sulphate occurred as sodium sulphate, then the latter would have comprised about 28 to 40 percent (average 32 percent) of total dustfall in 1976. Two distinctive types of particulate contaminants were observed in or on dustfall jars at stations 61020, 61022, and 61023: a whitish powder (possibly saltcake) on the sides of jars facing the mill in February, and moderate to heavy deposition of a black particulate substance (possibly bark char or lignite) in jars exposed in February and March. Very substantial decreases in total dustfall were recorded during the period (mid-June to late September) when the mill was not operating. The decline in sulphate levels was even more pronounced during this period. Total dustfall during mill shutdown averaged 15 tons per square mile per 30 days, compared with 42 tons for the rest of the year. Comparable figures for sulphate were 0.8 tons and 7.0 tons, respectively -- a nine-fold difference. A general decline in dustfall levels in Dryden is anticipated in 1977 following installation of new pollution control equipment at the mill.

(b) Sulphation Rates

Sulphation rates are measured by exposing small plastic plates coated with lead dioxide to the atmosphere for 30-day periods. Lead dioxide reacts with gaseous sulphur compounds in

the air to form lead sulphate. The quantity of lead sulphate formed is analytically determined and reported as milligrams of sulphur trioxide per hundred square centimeters per day ($\text{mg SO}_3/100 \text{ cm}^2/\text{day}$). The method is normally used to detect sulphur dioxide, but other reactive sulphur compounds, such as hydrogen sulphide and other organic sulphides, may also be converted to the sulphate form. Therefore, where more than one reactive sulphur-containing gas is present, sulphation rates represent the composite effect of all such contaminants.

Sulphation rates were determined at the same locations used for dustfall measurement (Figure 9). Monthly values are given in Table 6 and plotted in Figure 11. The highest rates occurred at station 61023, closest to the mill, with lesser amounts recorded at more remote points. As with dustfall, there was a sharp decline in sulphation rates during months when mill production was suspended.

ACKNOWLEDGEMENTS

Contributions and assistance from the following agencies is gratefully acknowledged:

- Air Quality Section, Laboratory Services Branch, for chemical analysis of vegetation and soil and for preparing and analysing sulphation plates.
- Regional Laboratory, Northwestern Region, for dustfall weight and sulphate determination and for chemical analysis of snow meltwater.
- Phytotoxicology Section, Air Resources Branch, for processing vegetation and soil samples.

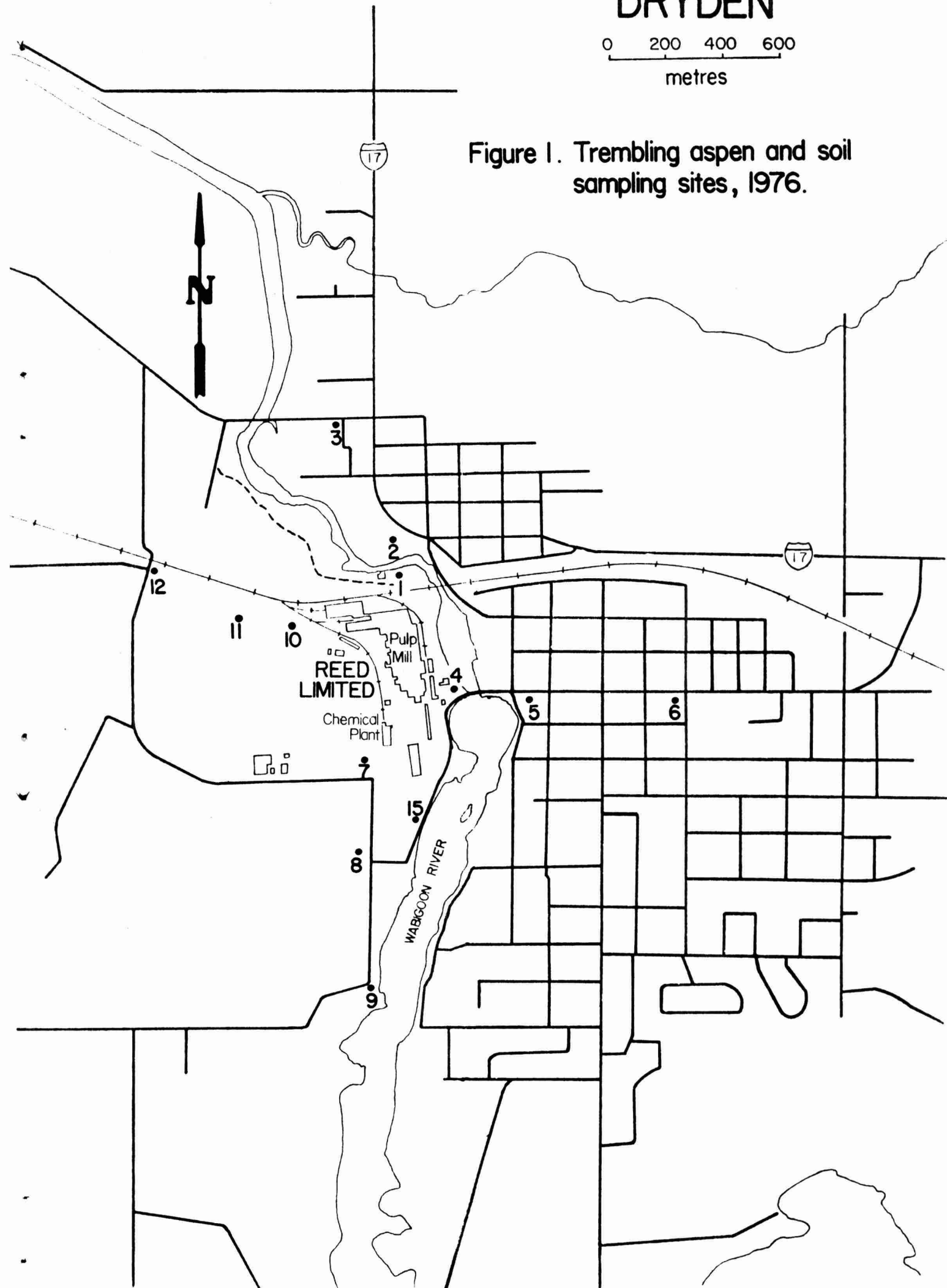
REFERENCES

1. Griffin, H. D. (1976). Air Quality, Dryden. Annual Report, 1975. Ontario Ministry of the Environment.
2. Ontario Ministry of the Environment (1977). Air Quality, Marathon. Annual Report, 1976.
3. Temple, P. J. and Linzon, S. N. (1977). Contamination of vegetation, soil, snow and garden crops by atmospheric deposition of mercury from a chlor-alkali plant. Proc. 11th Ann. Conf. on Trace Substances in Environ. Health (in press).
4. Goodman, G. T. and Roberts, T. M. (1971). Plants and soils as indicators of metals in the air. Nature 231;287-292.
5. Little, P. and Martin, M. H. (1974). Biological monitoring of heavy metal pollution. Environ. Pollut. 6:1-19.
6. Ontario Ministry of the Environment, (1977). Air Quality, Fort Frances. Annual Report, 1976.

DRYDEN

0 200 400 600
metres

Figure 1. Trembling aspen and soil sampling sites, 1976.



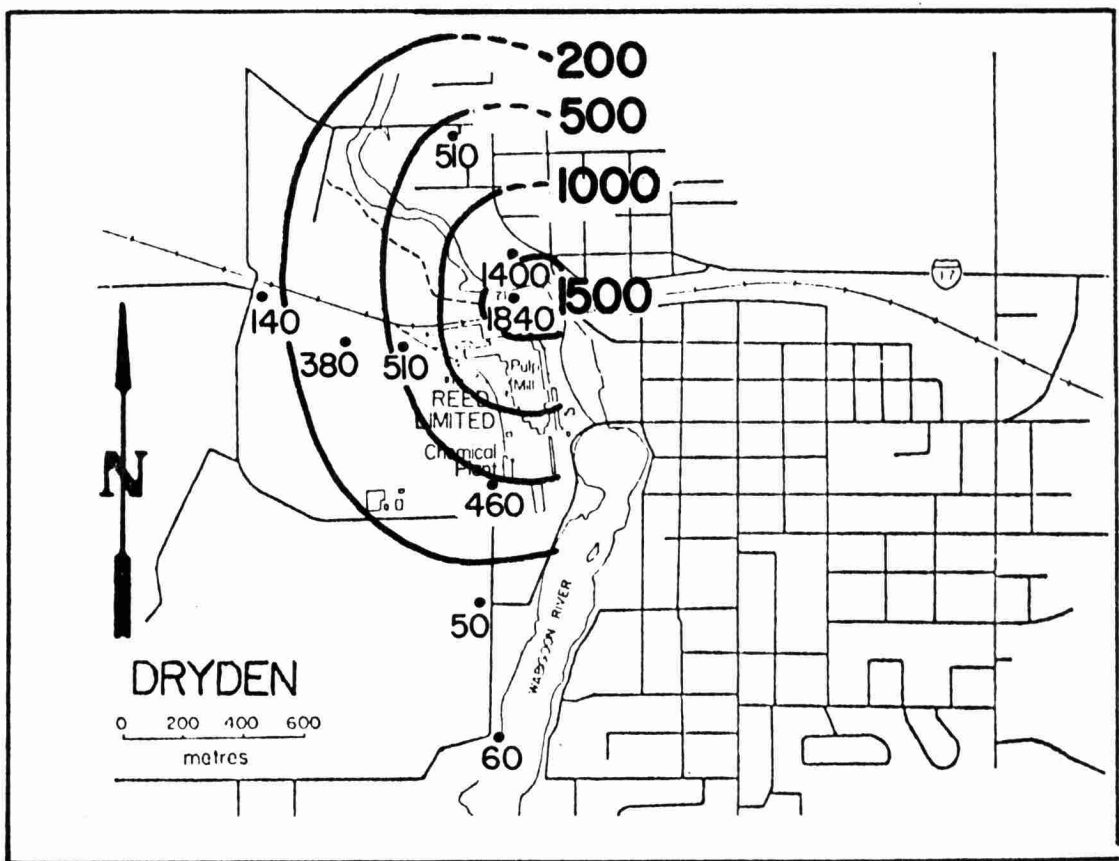


Figure 2a. Average mercury levels (ng/g, dry weight) in trembling aspen foliage, July, 1975.

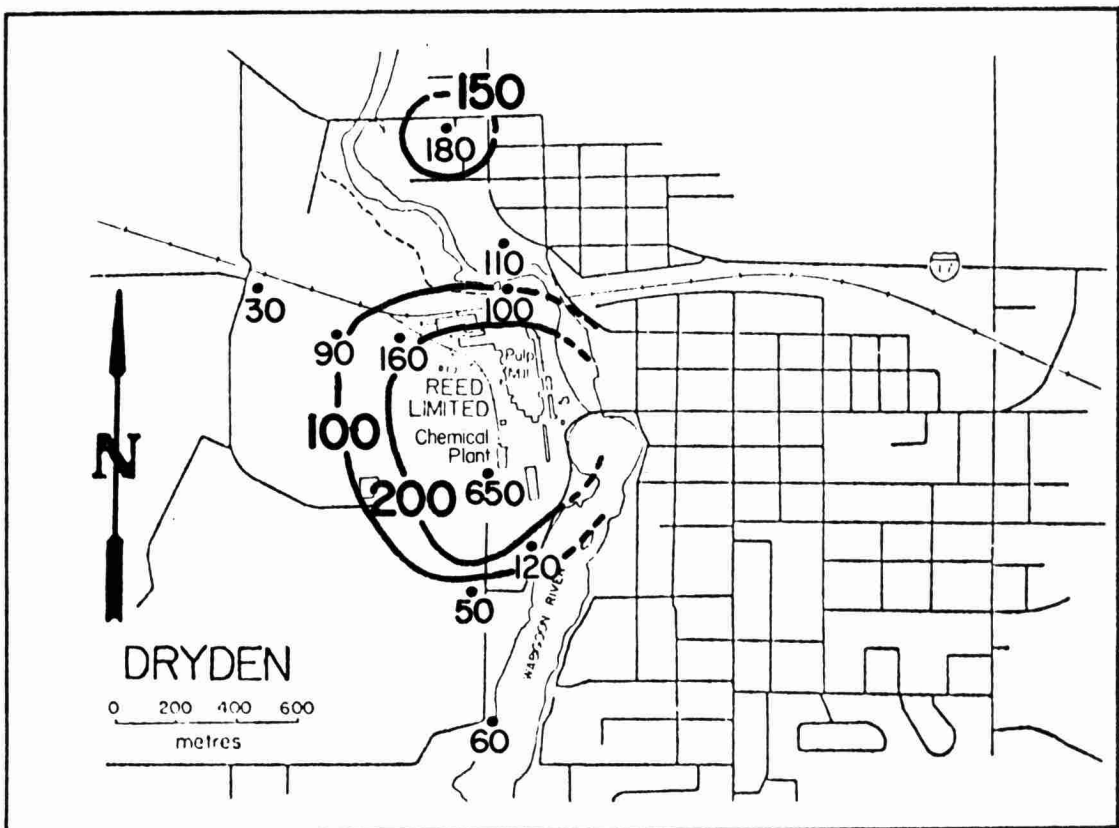
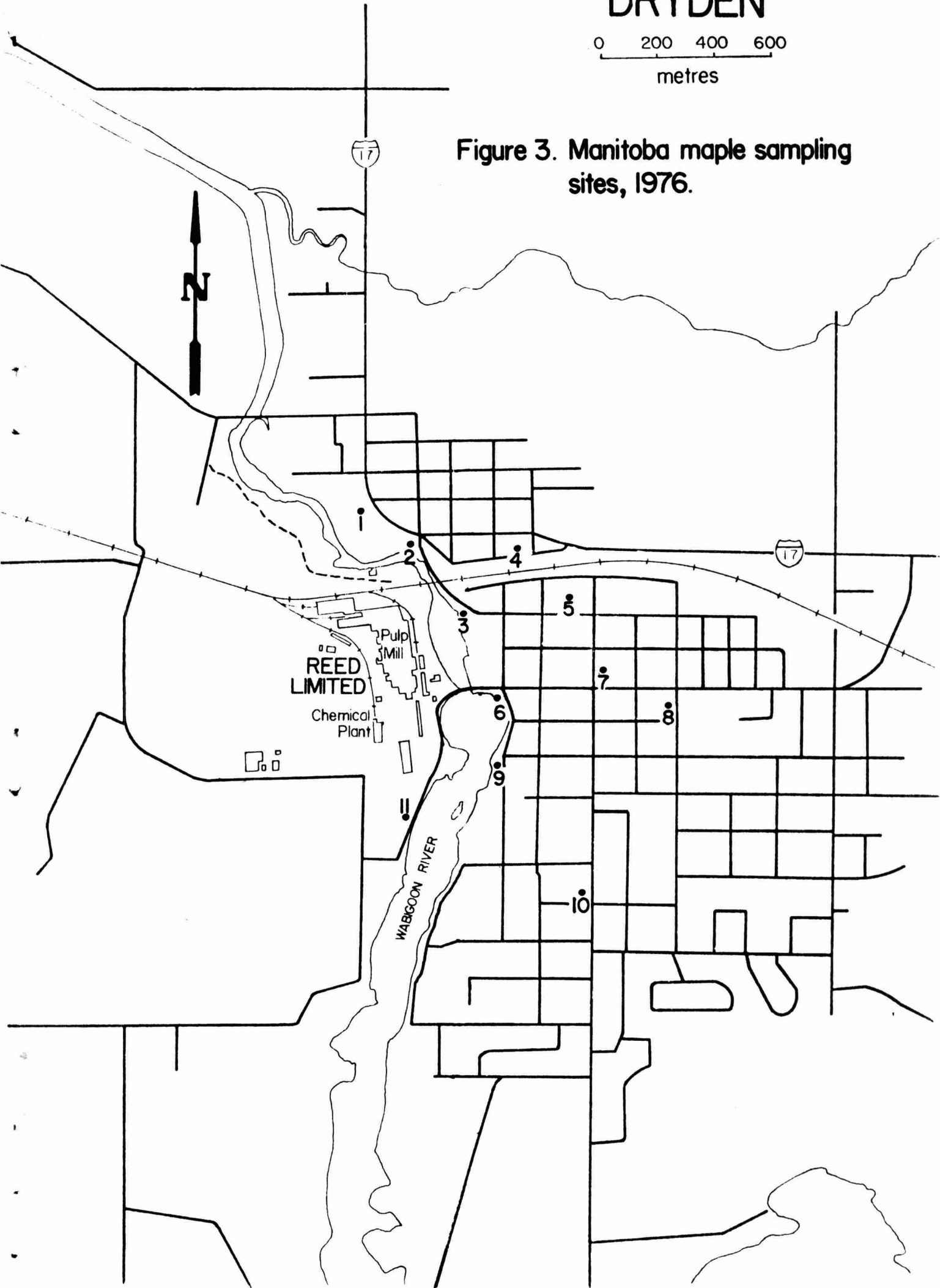


Figure 2b. Average mercury levels (ng/g, dry weight) in trembling aspen foliage, August, 1976.

DRYDEN

0 200 400 600
metres

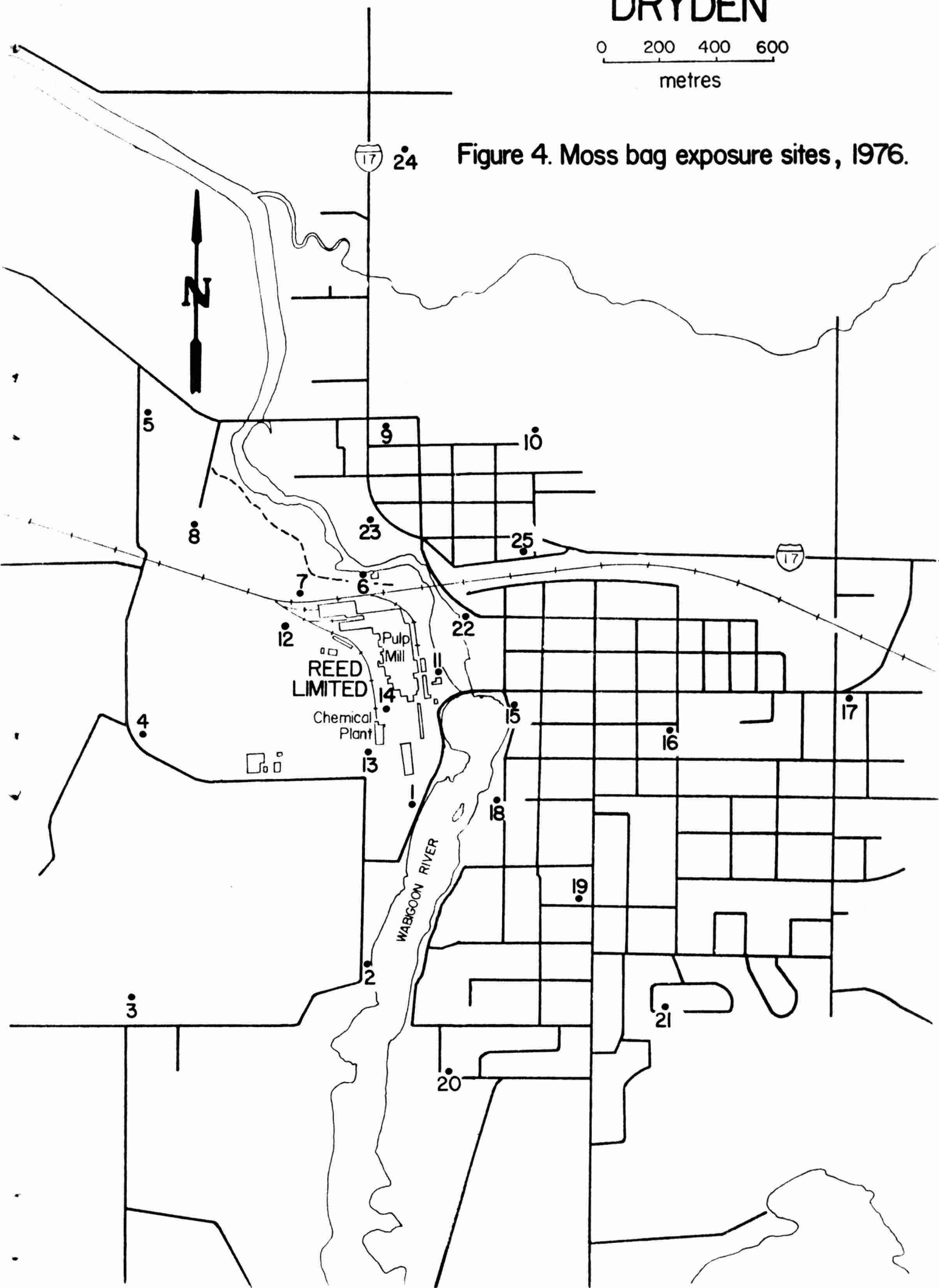
Figure 3. Manitoba maple sampling sites, 1976.



DRYDEN

0 200 400 600
metres

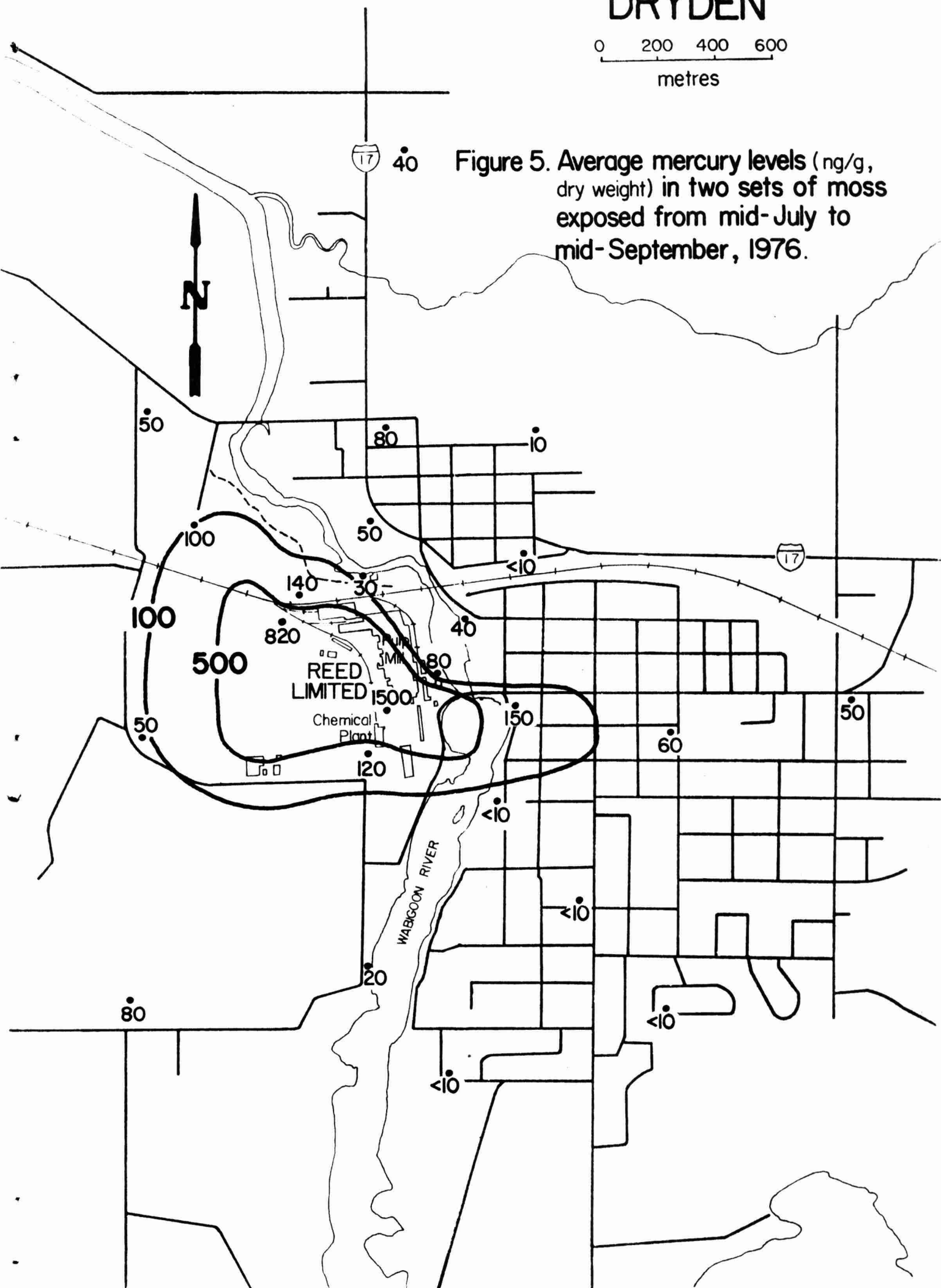
Figure 4. Moss bag exposure sites, 1976.



DRYDEN

0 200 400 600
metres

Figure 5. Average mercury levels (ng/g, dry weight) in two sets of moss exposed from mid-July to mid-September, 1976.



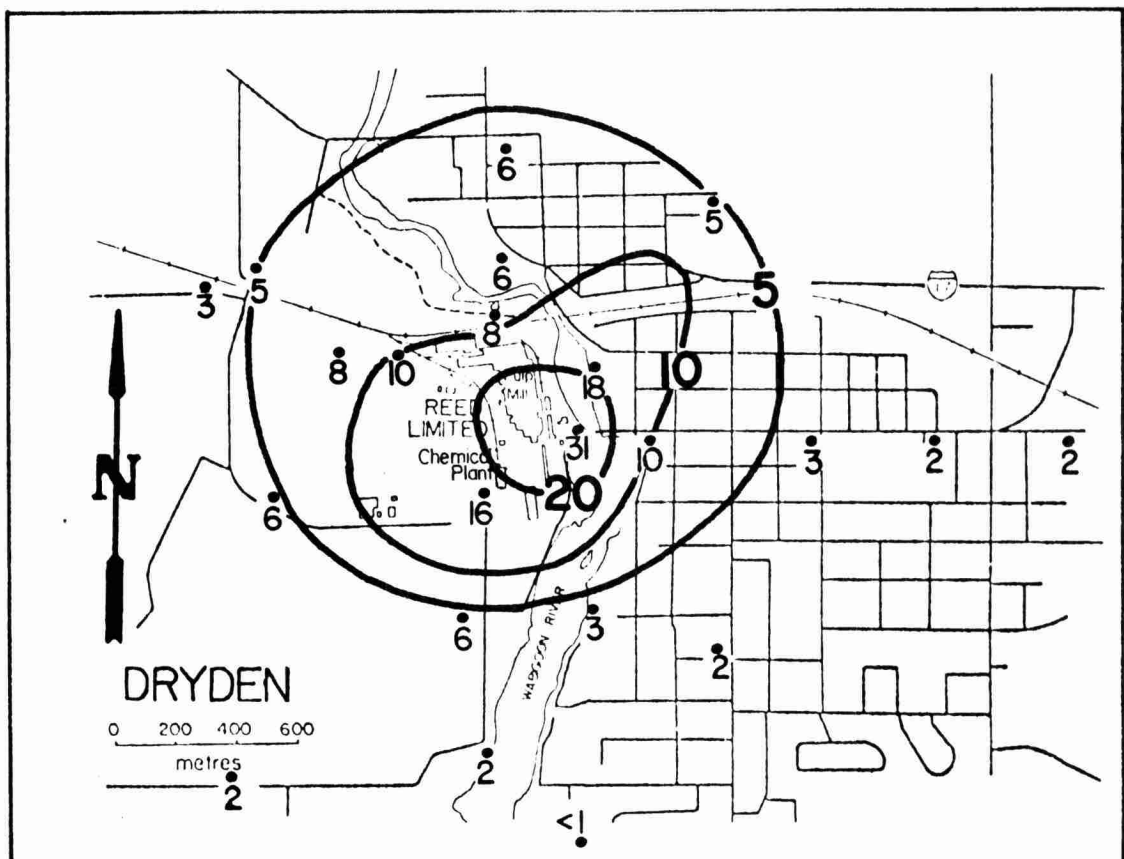


Figure 6a. Concentrations (mg/l) of calcium in snow, February, 1976.

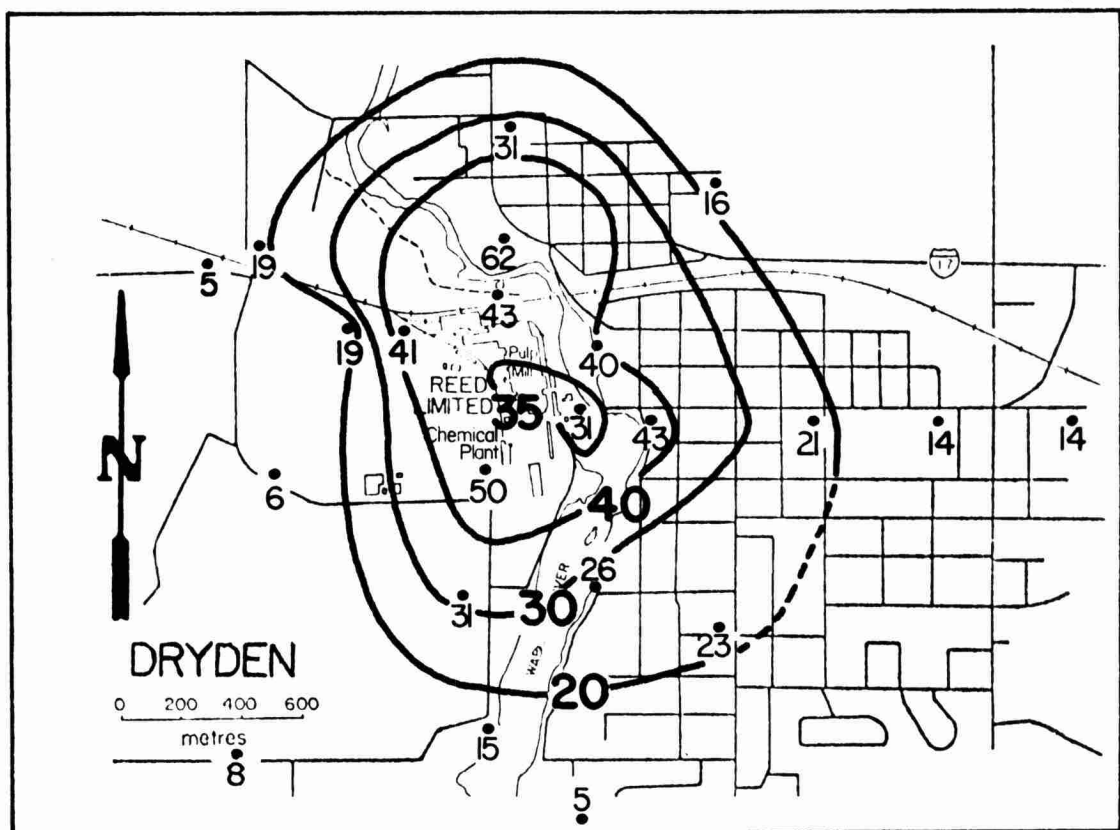


Figure 6b. Concentrations (mg/l) of sodium in snow, February, 1976.

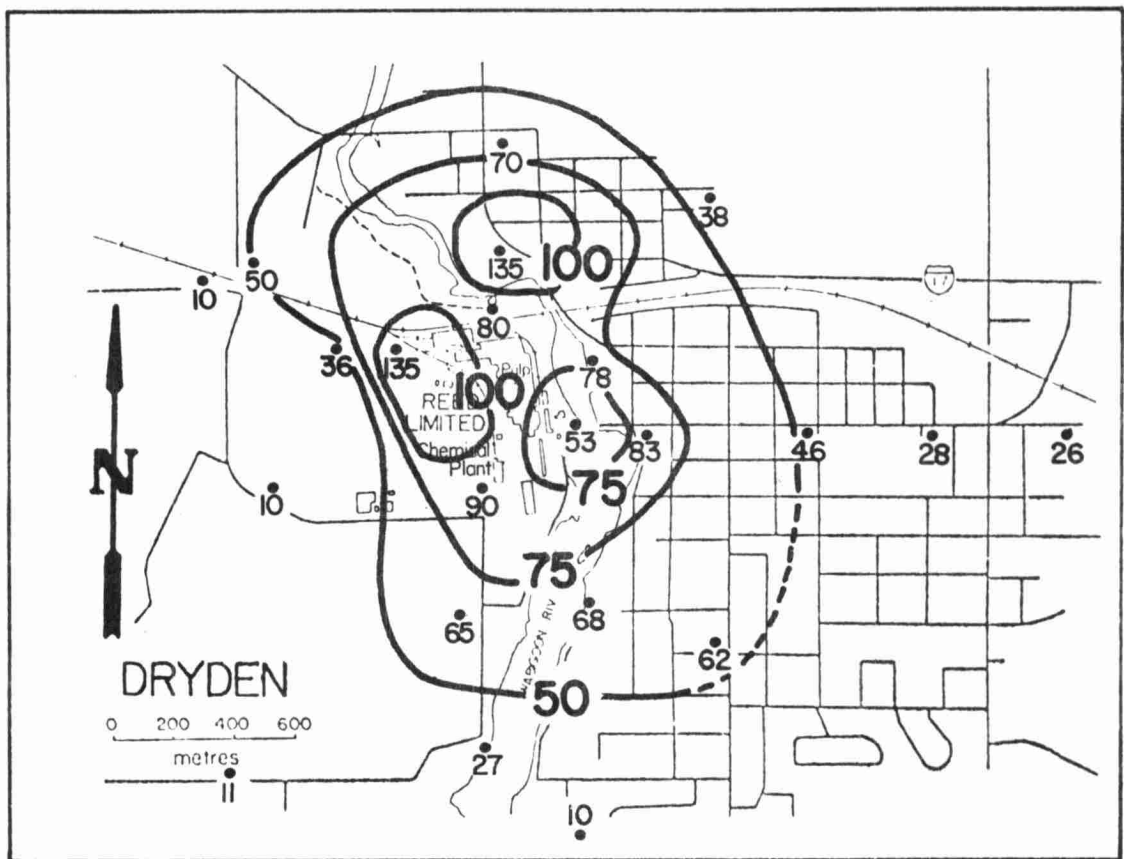


Figure 7a. Concentrations (mg/l) of sulphate in snow, February, 1976.

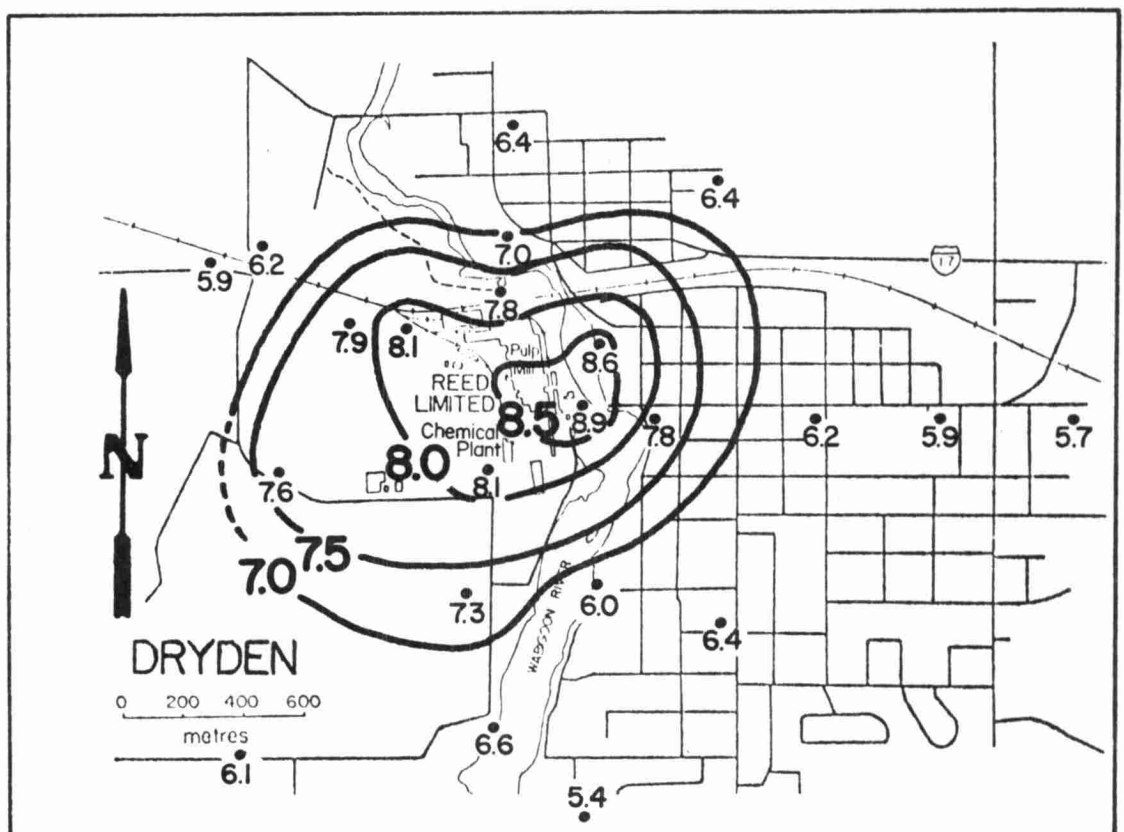


Figure 7b. pH levels in snow, February, 1976.

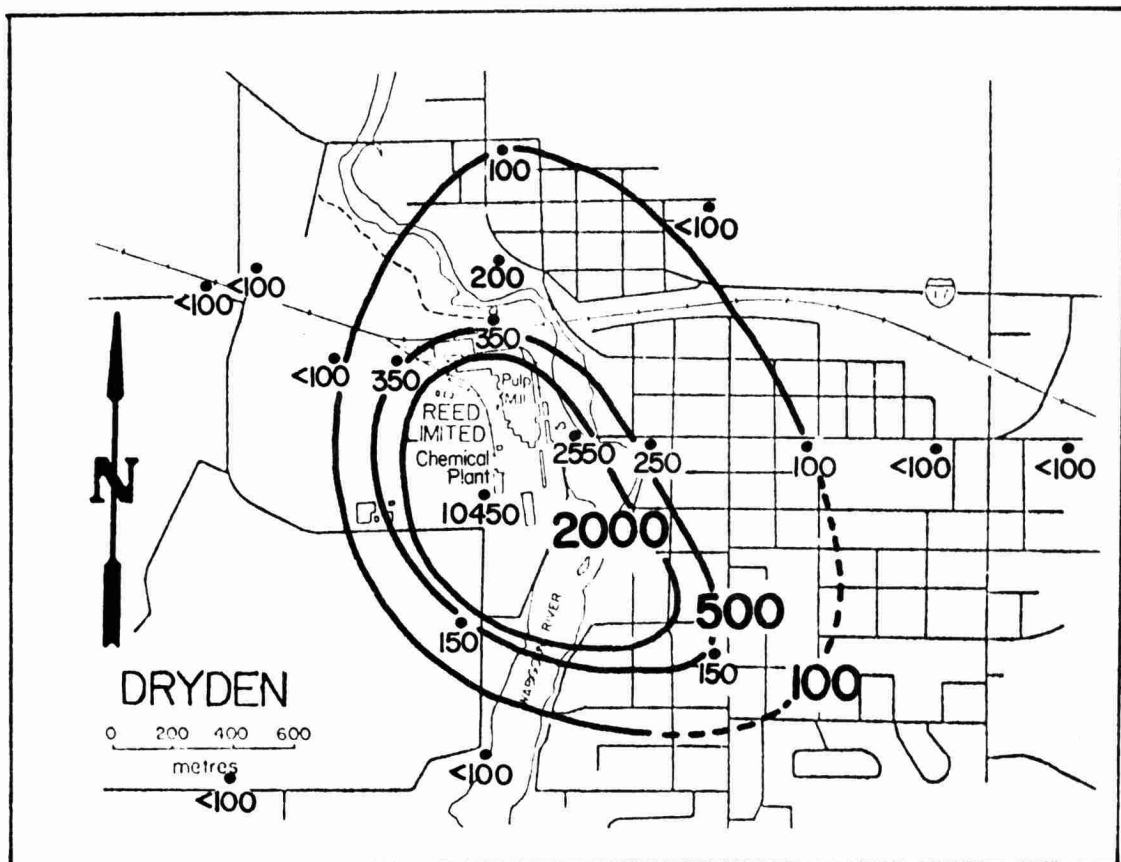


Figure 8a. Average concentrations (ng/l) of mercury in snow, January and March, 1975.

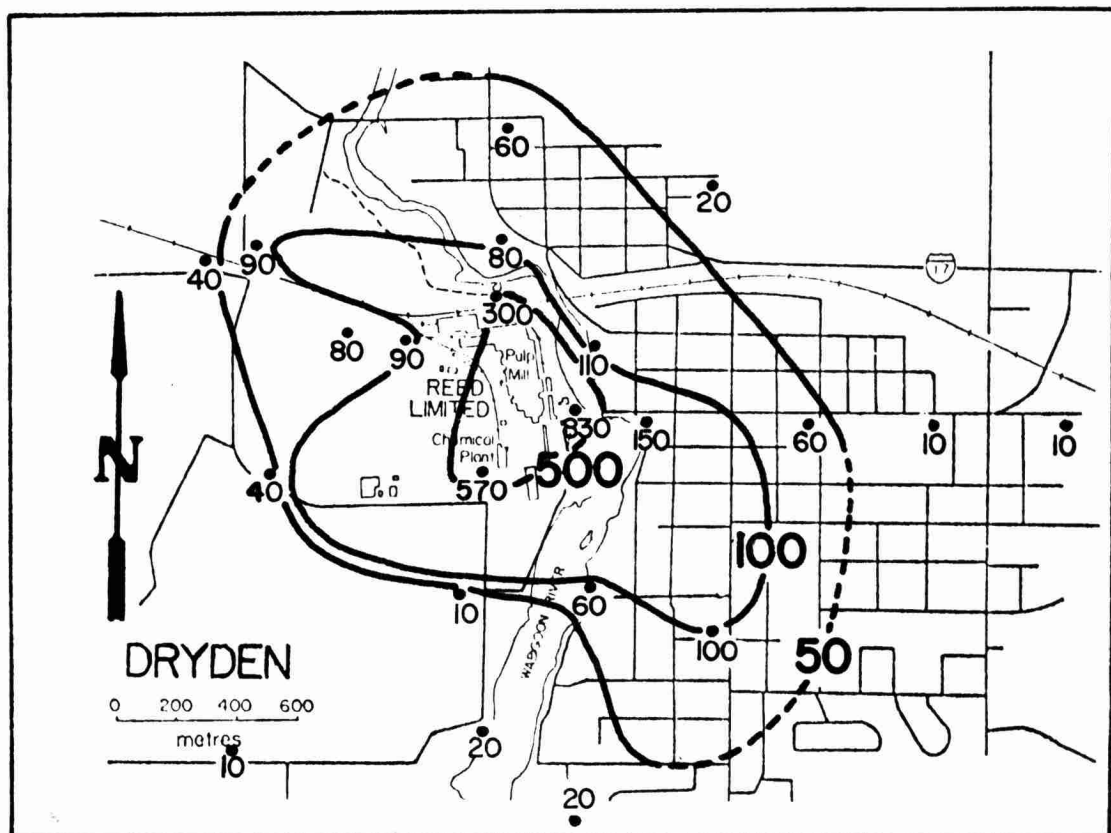
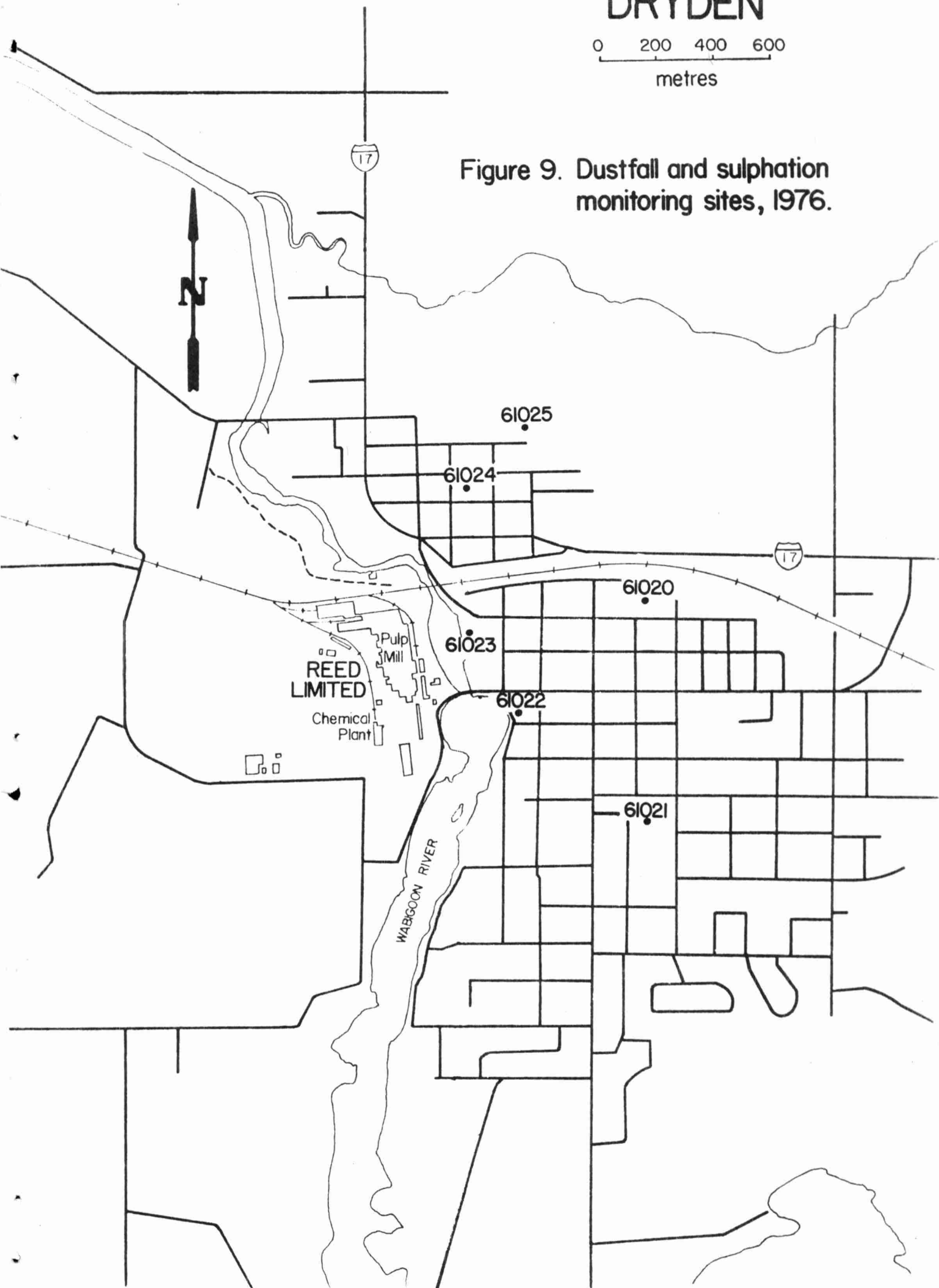


Figure 8b. Concentrations (ng/l) of mercury in snow, February, 1976.

DRYDEN

0 200 400 600
metres

Figure 9. Dustfall and sulphation monitoring sites, 1976.



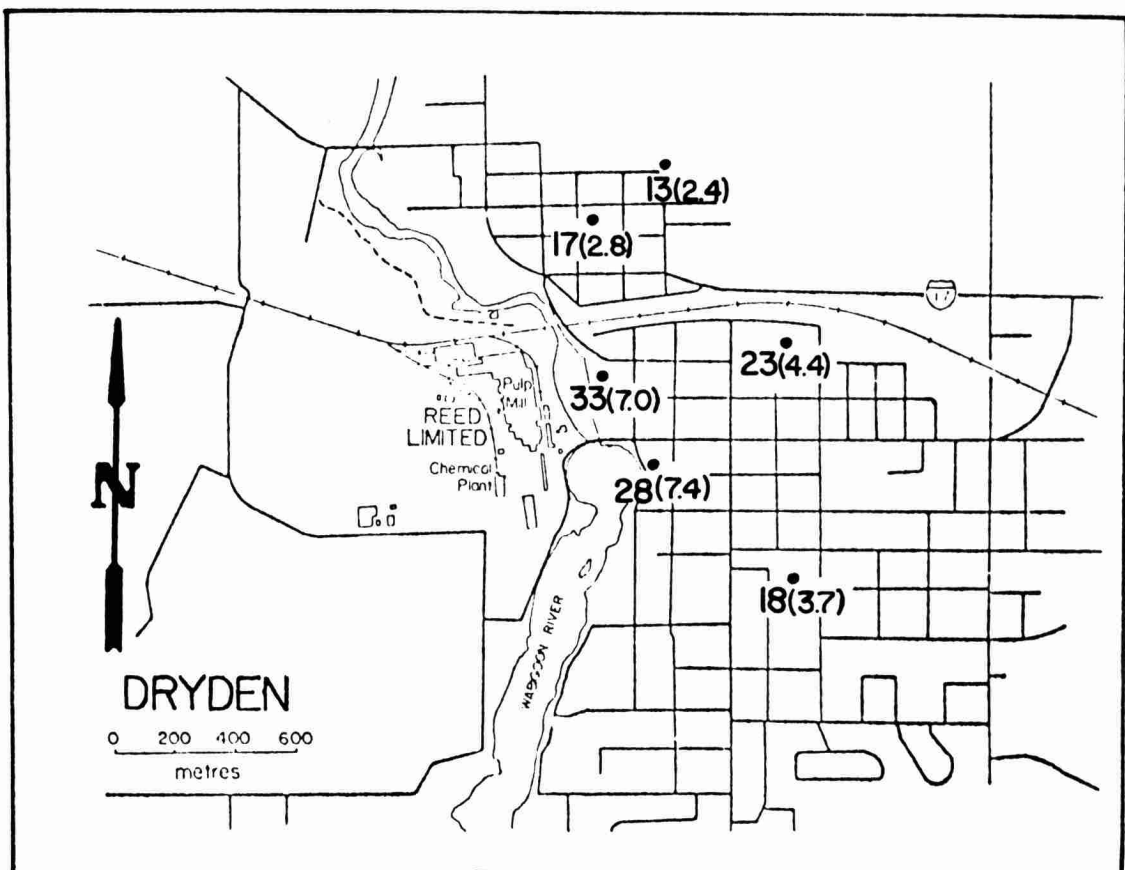


Figure 10. Average dustfall, 1976, with soluble sulphate in parentheses.(tons/square mile/ 30 days)

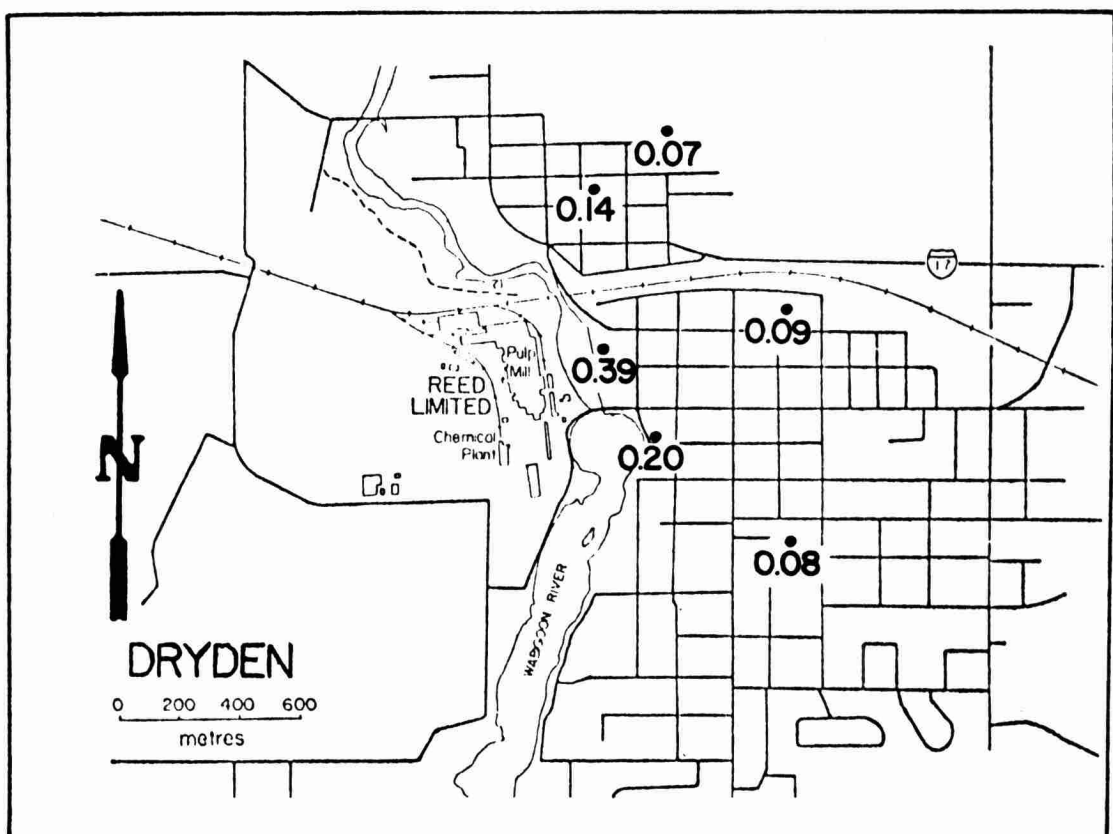


Figure 11. Average sulphation rate, 1976.
(mg SO₃/ 100 cm²/ day)

TABLE 1. Average mercury concentrations (ng/g, dry weight) in triplicate samples of trembling aspen foliage and soil (0-5, 5-10 cm) in Dryden, 1975 and 1976.

Site	Distance (metres) and direction from source*	Trembling aspen		Soil			
		1975	1976	1975		1976	
				0-5 cm	5-10 cm	0-5 cm	5-10 cm
1	550 N	1840	100	140	50	50	40
2	700 N	1400	110	40	40	70	50
3	1105 N	510	180	30	30	30	20
4	270 NE			250	50	390	170
	405 NE			180	80		
	880 NNE			70	50		
5	520 ENE			110	70	130	100
6	880 E			140	120	50	60
	960 ENE			230	40		
15	300 SSE		120			370	220
	350 ESE			120	40		
	900 ESE			140	30		
7	110 SW	460	650	1170	410	1900	1220
	230 WS			670	230		
8	425 SSW	50	50	50	50	30	30
9	880 S	60	60	50	50	40	20
10	220 NW	510	160	200	120	340	70
11	480 WNW	380	90	180	110	300	130
12	975 WNW	140	30	70	40	100	40
Control	7700 ENE	20	20	50	50	10	20
Control	10700 WNW	20	40	50	50	40	40

*Source arbitrarily designated as centre of Reed Limited chemical plant.

TABLE 2. Average levels of mercury, sodium (both in $\mu\text{g/g}$, dry weight) and chloride (% , dry weight) in triplicate samples of not washed Manitoba maple foliage at Dryden, August, 1976.

Site	Distance (metres) and direction from source*	Mercury	Sodium	Chloride
1	585 NNW	.03	41	.07
2	465 N	.08	65	.23
3	330 NE	.07	121	.29
4	625 NE	.05	118	.16
5	665 ENE	.08	59	.24
6	375 E	.08	123	.24
7	720 E	.18	35	.17
8	945 E	.41	52	.11
9	465 SE	.06	69	.11
10	985 SE	.09	72	.10
11	480 S	.10	96	.26
Control	5100 NW	< .01	46	.06
Control	6500 E	< .01	38	.12

*Source arbitrarily designated as recovery furnace stack at Reed Limited kraft mill.

TABLE 3. Concentrations of calcium, chloride, mercury and sodium in moss exposed in bags during July-September, 1976.*

Sampling station	Calcium	Chloride	Mercury	Sodium
1	825	.04	.07	120
2	1550	.02	.02	225
3	1660	.02	.08	200
4	1820	.02	.05	190
5	1460	.04	.05	110
6	1510	.04	.03	180
7	1035	.04	.14	105
8	920	.02	.10	50
9	1000	-	.08	110
10	920	.02	.01	110
11	1395	.02	.08	135
12	3085	.02	.82	205
13	810	.08	.12	110
14	1645	.02	1.50	260
15	2520	.02	.15	280
16	130	.04	.06	180
17	160	.04	.05	155
18	85	.02	< .01	215
19	110	.02	< .01	190
20	100	.02	< .01	165
21	60	.02	< .01	150
22	1400	.02	.04	305
23	910	.03	.05	75
24	830	.04	.04	75
25	330	.02	< .01	125
26 (control)	1165	.02	< .01	155
27 (control)	-	-	-	-

*Values are averages for two exposure periods: July 13-August 17 and August 17-September 13. Concentrations are in $\mu\text{g/g}$, dry weight basis, for calcium, mercury and sodium, and in percent, dry weight, for chloride.

TABLE 4. Levels of calcium, mercury, sodium, sulphate and pH in snow collected at Dryden, February 25-26, 1977.

Site	Distance (metres) and direction from source*	Calcium (mg/l)	Mercury (ng/l)	Sodium (mg/l)	Sulphate (mg/l)	pH
3	350 N	8	300	43	80	7.8
18	575 N	6	80	62	135	7.0
20	865 N	6	60	31	70	6.4
21	1455 N	2	30	7	11	5.8
22	2015 N	2	30	5	9	5.0
27	320 NE	18	110	40	78	8.6
19	930 NE	5	20	16	38	6.4
10	190 E	31	830	31	53	8.9
11	415 E	10	150	43	83	7.8
12	945 E	3	60	21	46	6.2
13	1325 E	2	10	14	28	5.9
14	1735 E	2	10	14	26	5.7
15	990 SE	2	100	23	62	6.4
17	655 SSE	3	60	26	68	6.0
8	1090 S	2	20	15	27	6.6
16	1410 S	<1	20	5	10	5.4
6	255 SSW	16	570	50	90	8.1
7	690 SSW	6	10	31	65	7.3
9	1500 SW	2	10	8	11	6.1
28	870 WSW	6	40	6	10	7.6
4	300 W	10	90	41	135	8.1
5	550 W	8	80	19	36	7.9
24	1100 WNW	3	40	5	10	5.9
25	1500 WNW	2	20	7	13	5.5
26	2000 WNW	2	10	2	3	4.9
23	1000 NW	5	90	19	50	6.2
Control	10700 WNW	<1	10	<1	<1	3.0
Control	7700 ENE	<1	20	<1	<1	3.7

*Source arbitrarily designated as recovery furnace stack at Reed Limited kraft mill.

TABLE 5. Total dustfall and soluble sulphate in dustfall, Dryden, 1976.

Station	Location	Distance (metres) and direction from source*	Total dustfall (tons/square mile/30 days)												Average
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
61020	Kirkpatrick/Queen	895 ENE	18	36 ⁺	27	24	15	19	13	24	17	39	35	12	23
61021	Casimir/St. Charles	1010 ESE	14	35	22	11	13	11	16	10	11	25	31	18	18
61022	Earl/Albert	430 ESE	24	42	48	27	26	-	7	27	18	31	36	24	28
61023	King/Wabigoon River	305 NE	20	62	62	32	-	32	21	13	12	39	42	23	33
61024	Mary/Florence	735 NNE	14	36	-	14	18	13	9	9	14	19	20	17	17
61025	Park/Second	960 NNE	9	19	15	14	-	23	-	9	8	14	14	9	13
Soluble sulphate in dustfall (tons/square mile/30 days)															
61020	Kirkpatrick/Queen	895 ENE			9.2	6.7	0.9	1.4	0.3	1.4	0.3	5.3	14.1	4.1	4.4
61021	Casimir/St. Charles	1010 ESE			8.3	3.6	1.7	0.8	0.3	1.0	0.3	8.2	7.9	5.0	3.7
61022	Earl/Albert	430 ESE			23.4	10.4	3.6	-	0.2	1.2	0.3	9.6	10.0	7.5	7.4
61023	King/Wabigoon River	305 NE			22.9	6.2	1.9	1.9	0.7	1.4	0.3	11.2	16.5	6.5	7.0
61024	Mary/Florence	735 NNE			-	1.9	1.7	1.2	0.3	2.0	0.3	4.7	5.3	7.5	2.8
61025	Park/Second	960 NNE			4.9	2.9	1.6	1.0	-	1.2	0.3	3.4	2.6	3.8	2.4

*Source arbitrarily designated as recovery furnace stack, Reed Limited kraft mill.

+Values above criteria of 20 (monthly) or 13 (annual average) are underlined.

TABLE 6. Sulphation rate (mg SO₃/100 cm²/day), Dryden, 1976

Station	Location	Distance (metres) and direction from source*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
61020	Kirkpatrick/Queen	895 ENE								.04	.03	.18	.06	.14	.09
61021	Casimir/St. Charles	1010 ESE								.04	.03	.16	.10	.14	.08
61022	Earl/Albert	430 ESE	.32	.26	.34	.23	.18	.18	.03	.06	.03	.34	.22	.26	.20
61023	King/Wabigoon River	305 NE	.40	.66	.56	.55	.64	.30	.03	.04	.03	.68	.52	.32	.39
61024	Mary/Florence	735 NNE	.08	-	.18	.23	.28	.12	.03	.08	.03	.14	.18	.14	.14
61025	Park/Second	960 NNE								.06	.03	.08	.06	.14	.07

*Source arbitrarily designated as recovery furnace stack, Reed Limited kraft mill.

LABORATORY LIBRARY



96936000118536